MI-2-20

FIELD INVESTIGATIONS OF UNCONTROLLED HAZARDOUS WASTE SITES

FIT PROJECT

TASK REPORT TO THE ENVIRONMENTAL PROTECTION AGENCY CONTRACT NO. 68-01-6056

Hydrogeologic Report on the
Federal Marine Terminals Property
Riverview, Michigan
TDD# F5-8007-5C

March, 1982

ecology and environment, inc.

International Specialists in the Environmental Sciences

Circulation
1. M Mutnam
2. T.E. Yeates
3.
4.
5.

Region V
FIT Performance Evaluation Form

Date: 4/6/82

From: Mike Mutnam

To: T. E. Yeates, FIT
Deputy Project Officer

TDD F5- 8007-5c

Facility Name and Location: SASF/FMT, Riverview, Michigan

This evaluation is for the following FIT activity: Conduct an initial hydrogeologic field study of the Federal Marine Terminals property, Riverview, Michigan

1) Rate activity in regards to quality, timeliness, and completeness

1, Unsatisfactory 2, Below Average (3) Average 4, Above Average 5, Outstanding

Circle one 1 2 3 4 5

2) What are the strong points of the report? Discusses contamination sources and movements

3) What are the weak points of the report? Needed major rewriting before it reached this point.

4) How will the report be used? As part of enforcement action

5) Other comments: FIT was asked not to write this report, wrote it and then attempted to hide it from the assigned attorney. This should not happen again.

REPORT DELIVERED TO CLIENT ON 3/31/82, COMMENTS DUE BY 4/9/82

Signature of evaluator Michael Mutnam

Form F-2 - (6/81)

In accordance with TDD# F5-8007-5C, Ecology and Environment, Inc. has completed an initial hydrogeologic field study of the Federal Marine Terminals property in Riverview, Michigan. Objectives of the study included identification of contaminants present in soil and groundwater, determination of groundwater flow characteristics, and evaluation of the potential for off-site migration of contaminants.

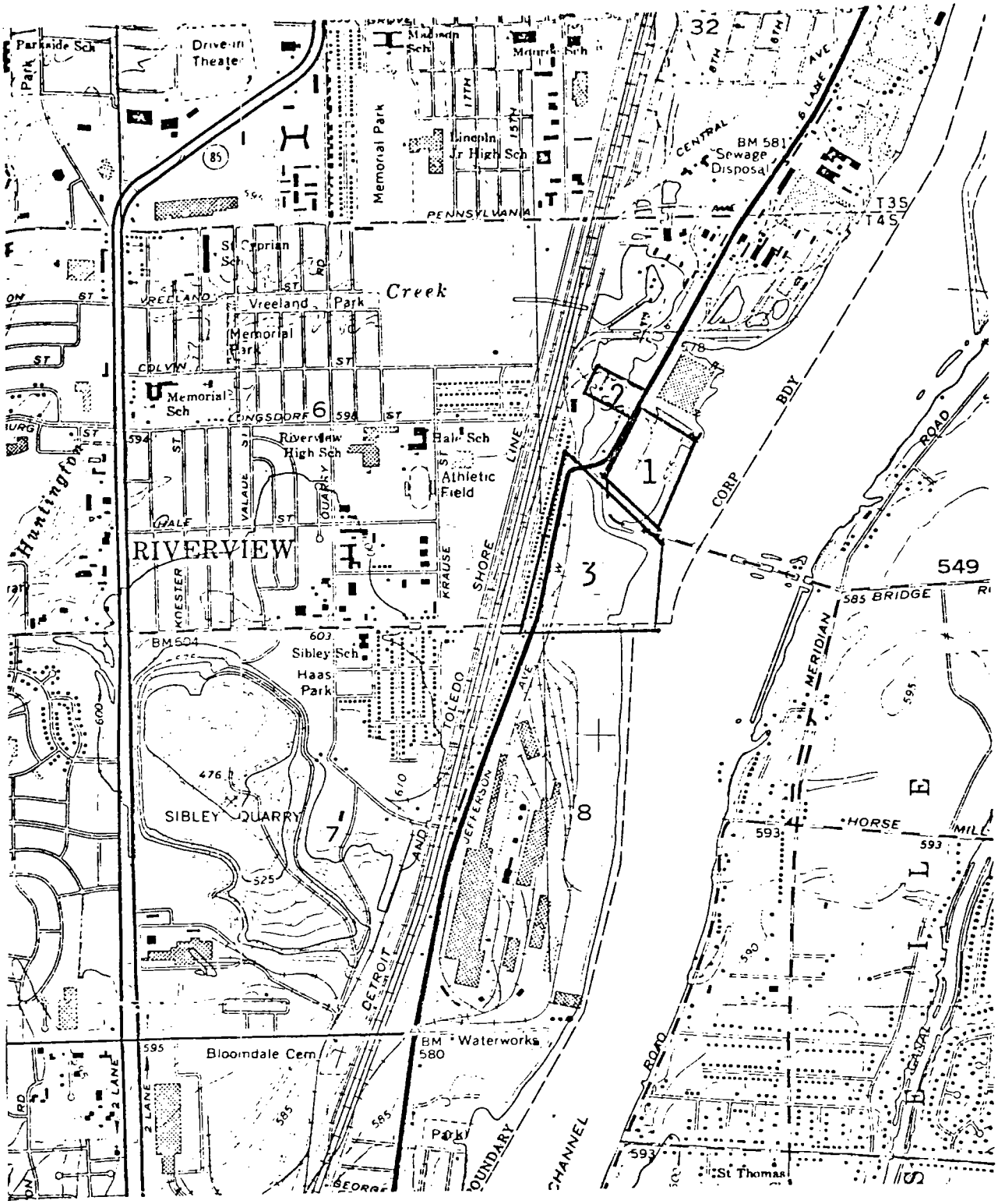
The property in question is an approximately 30 acre parcel along the Trenton Channel of the Detroit River. It is bounded on the east by the Detroit River, on the south by the Riverview boat dock, on the west by Jefferson Avenue, and on the north by the Firestone Steel plant (see locator map). Fill material was deposited on the site by unidentified parties over a period of many years. The exact time frame of filling operations is unknown but is believed to be during the 1950's and early 1960's.

Contamination and buried steel drums were encountered by workers during the initial phase of site development for a facility planned by Federal Marine Terminals. Further development was stopped at that time and the site remains inactive to date.

The study, as authorized by the United States Environmental Protection Agency (USEPA), has consisted of three major components involving data collection on the property. These components included geophysical site investigation, soil boring and well installation, and groundwater sampling.

Geophysical Testing

The geophysical testing portion of the study was subcontracted to Technos, Inc. Technos personnel utilized electromagnetic (EM) conductivity and magnetometer to characterize the site. The introduction of contaminants into a groundwater system can increase the ease with which electrical currents pass through the soil. By measuring the bulk ground conductivity, EM was used to delineate areas of potential groundwater contamination. The magnetometer was used to detect the presence of buried ferrous materials (i.e., steel drums).



Site Locations; 1-F.M.T., 2-Firestone,
3-McLouth Steel

Geophysical Testing (continued)

Figure 1 shows the spatial distribution of magnetic anomalies across the site. As is depicted in this figure, the highest accumulation of buried ferrous materials exists in the northeast quadrant of the property. Fewer anomalies were detected across the central portion of the site. The southwest and western portions of the area showed few or no anomalies.

Figures 2A, 2B, and 2C are computer generated, 3-dimensional views of the site showing the relative conductivities of the material present. Figures 3A and 3B are contour plots of the same data. As seen in these figures, the northeast and eastern portions of the site show significant increases in conductivity. According to Technos, "conductivities about 60 mm/m appear to be indicative of the clays present in the area". These conductivities found in background clays are nearly one order of magnitude less than the conductivities measured on the northeast portion of the site. Figure 3B magnifies areas along the Trenton Channel where areas of high conductivity meet the river.

With this information, we were able to design our monitoring network to pick up the major areas of high conductivity while avoiding magentic anomalies.

Soil Boring and Well Installation

In order to determine the geologic properties of the site and define the cause of the increased conductivities on site, a network of soil borings and monitoring well installation were designed. Toledo Testing Laboratory, Inc. was contracted to perform the boring and well installation as well as the soil testing. The network (see Plate 1) consisted of 19 borings into which wells were installed. The borings were done utilizing 3 inch solid stem augers. All augers were decontaminated with a hot water wash and acetone rinse between borings. Soil samples were taken using a standard 2 inch outer diameter split spoon sampler which had been decontaminated. Eight soil samples were selected for chemical analysis.

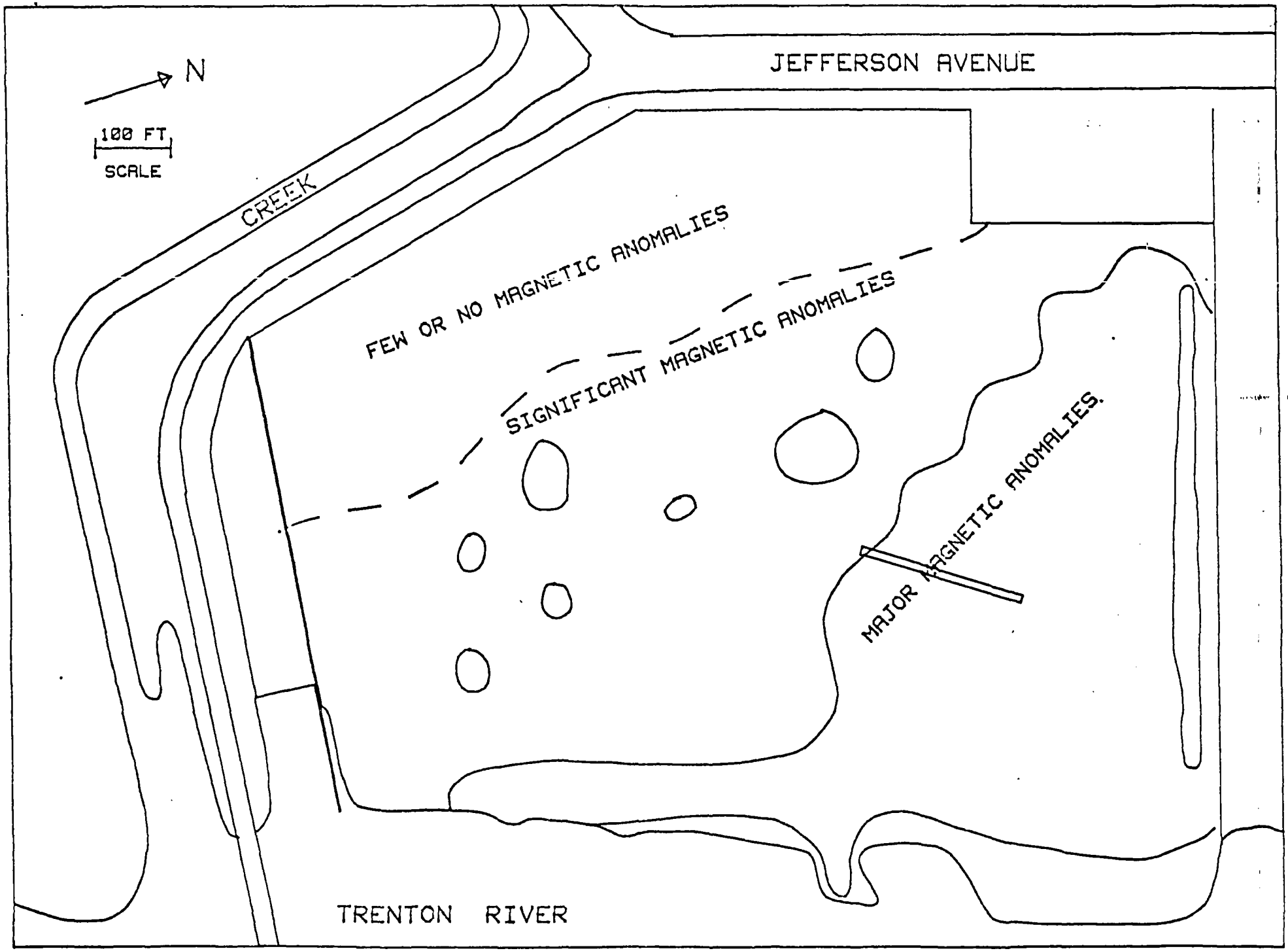


Figure 1 : F.M.T. Site; Magnetic Anomaly Distribution

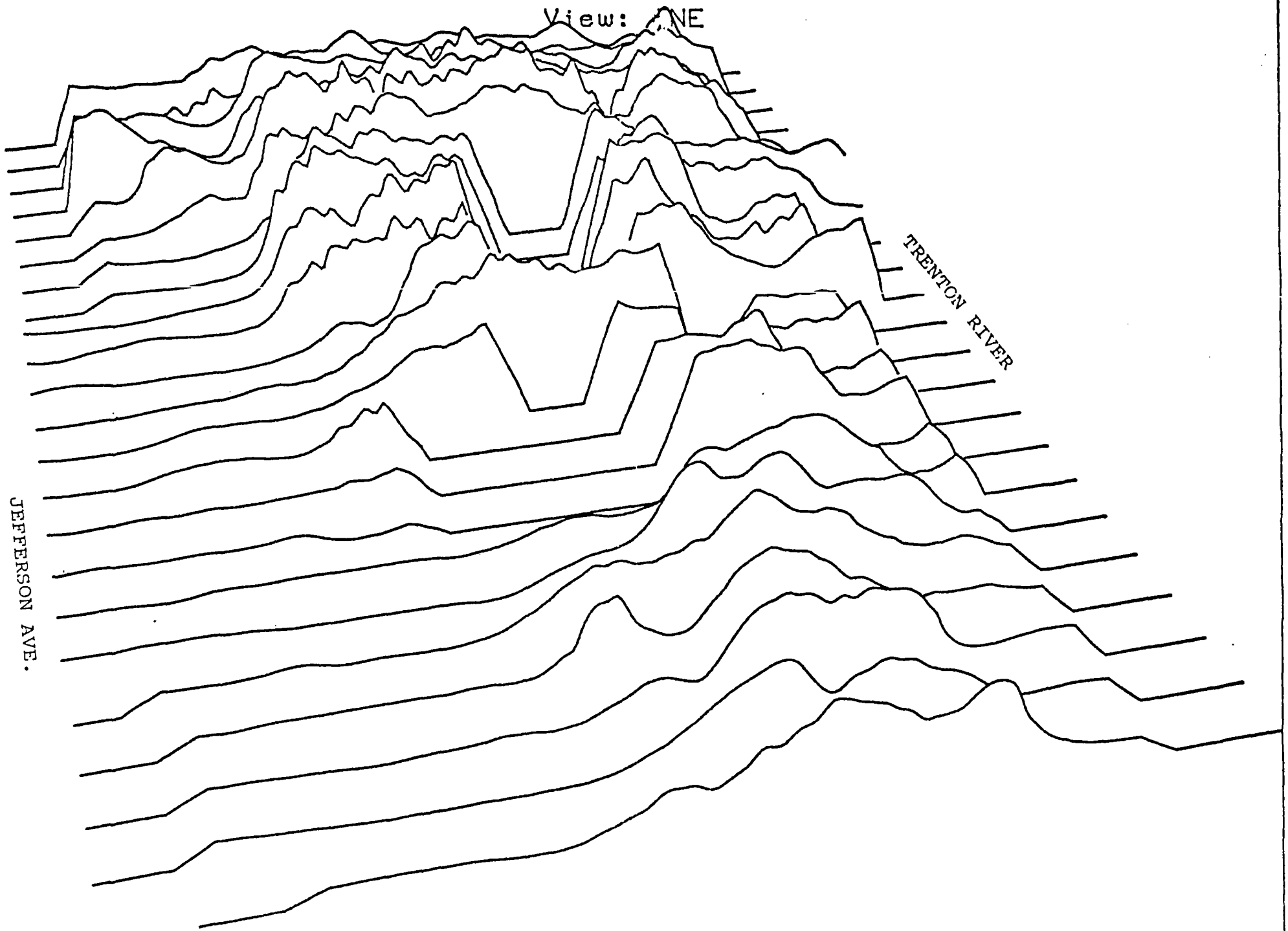


Figure 2-A: F.M.T. Site; 3-Dimensional Conductivity Plot, northeast view.
Figure is approximately to scale, 1000 by 1200 feet.

GROUND CONDUCTIVITY

TECHNOS INC, MIAMI

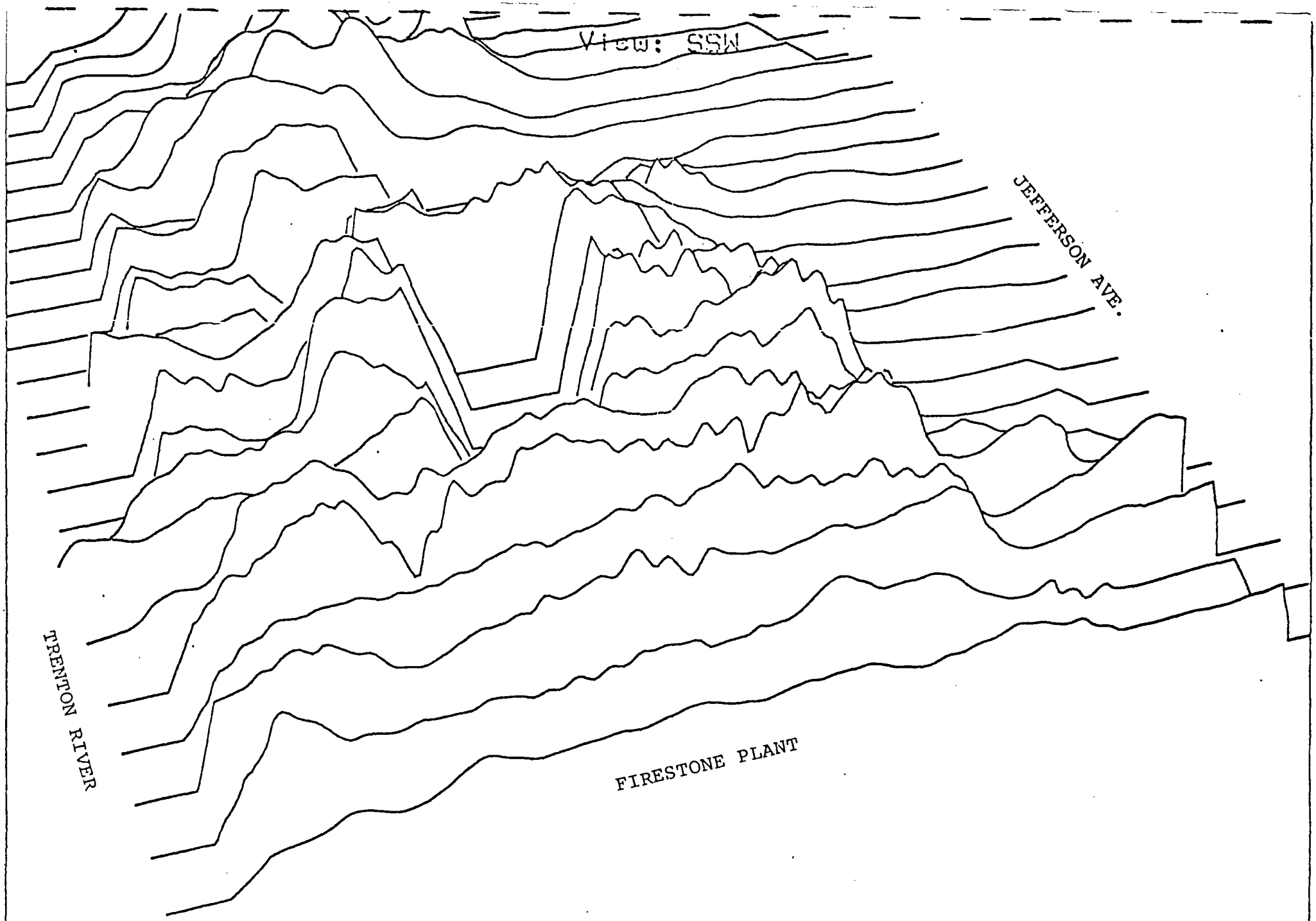


Figure 2 B: F.M.T. Site; 3-Dimensional Conductivity Plot, south-southwest view.
Figure is approximately to scale, 100 by 1200 feet.

GROUND CONDUCTIVITY

TECHNOS INC, MIAMI

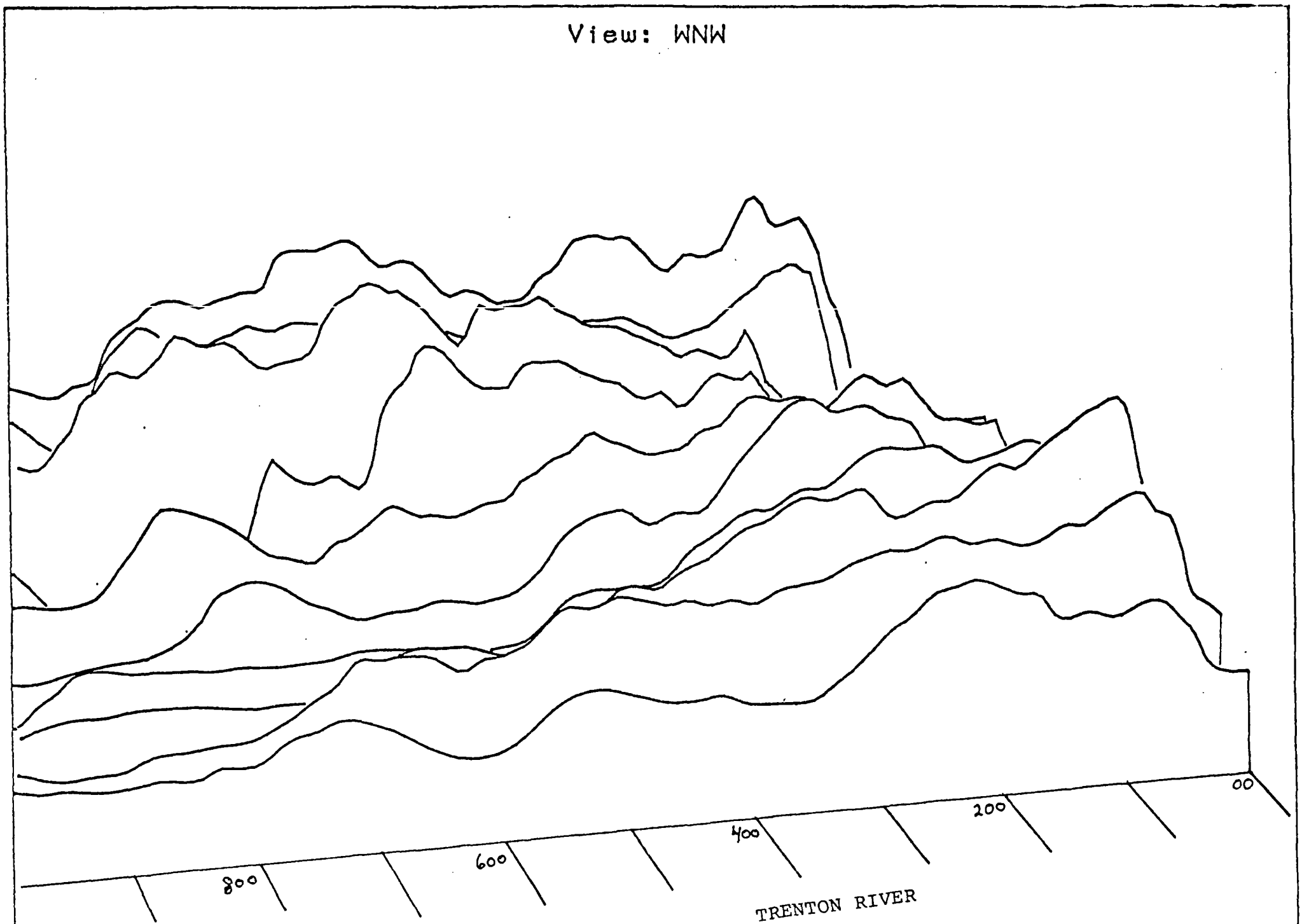


Figure 2C: F.M.T. Site; 3-Dimensional Conductivity Plot, Northeast corner.
Indicated scale is in feet.

GROUND CONDUCTIVITY

TECHNOS INC, MIAMI

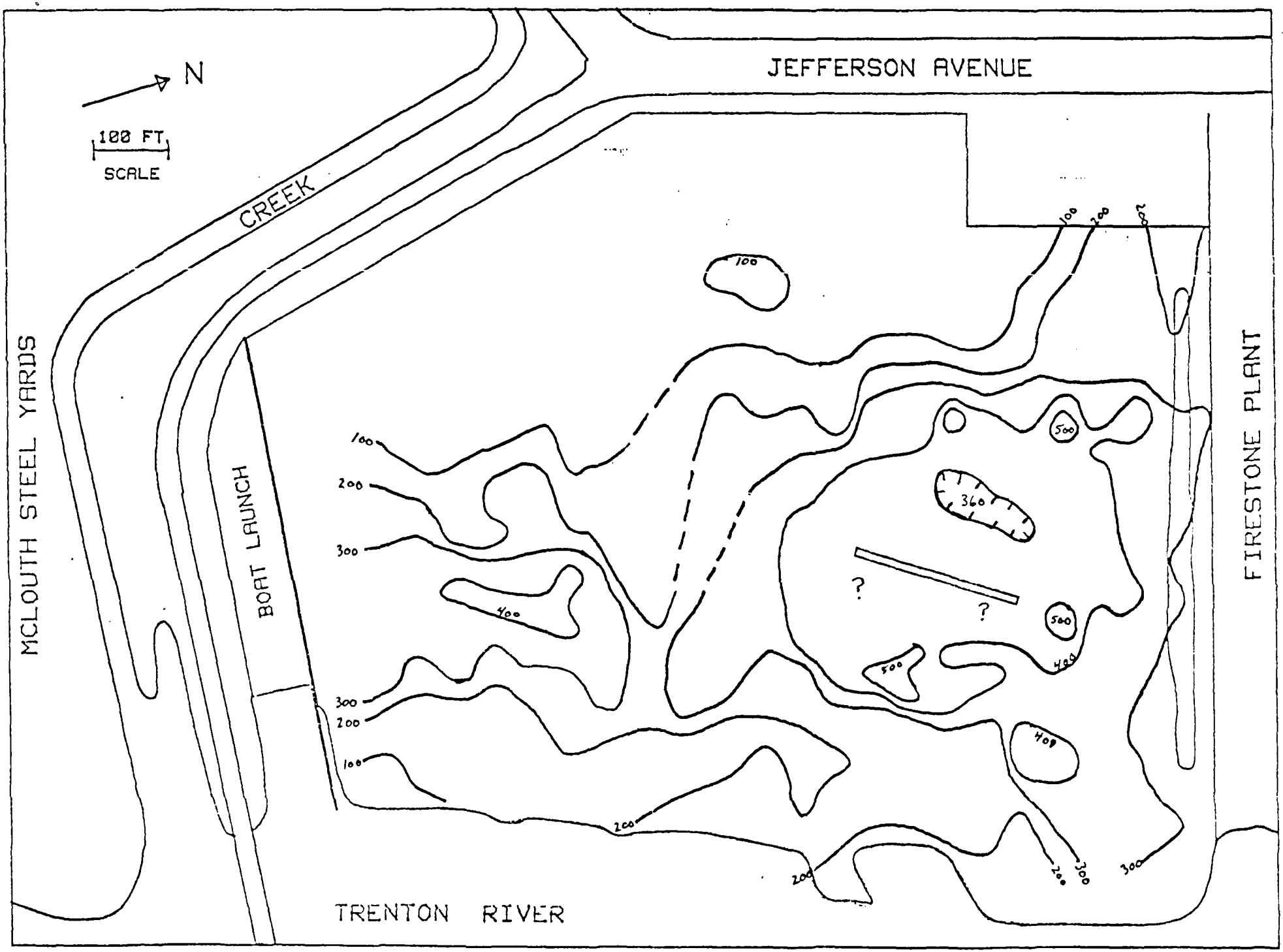


Figure 3A: F.M.T. Site; Generalized Ground Conductivity Contour Plot.

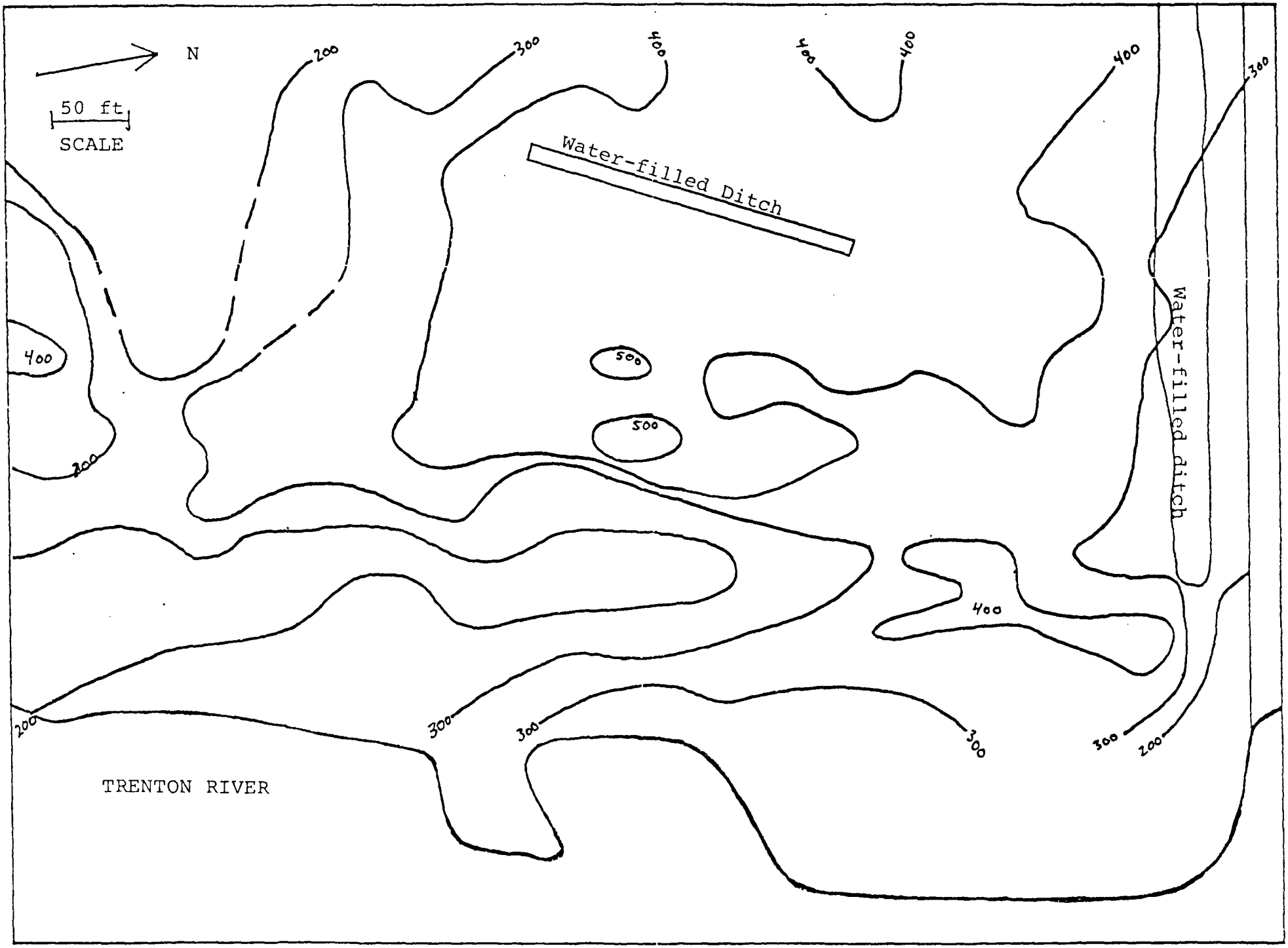
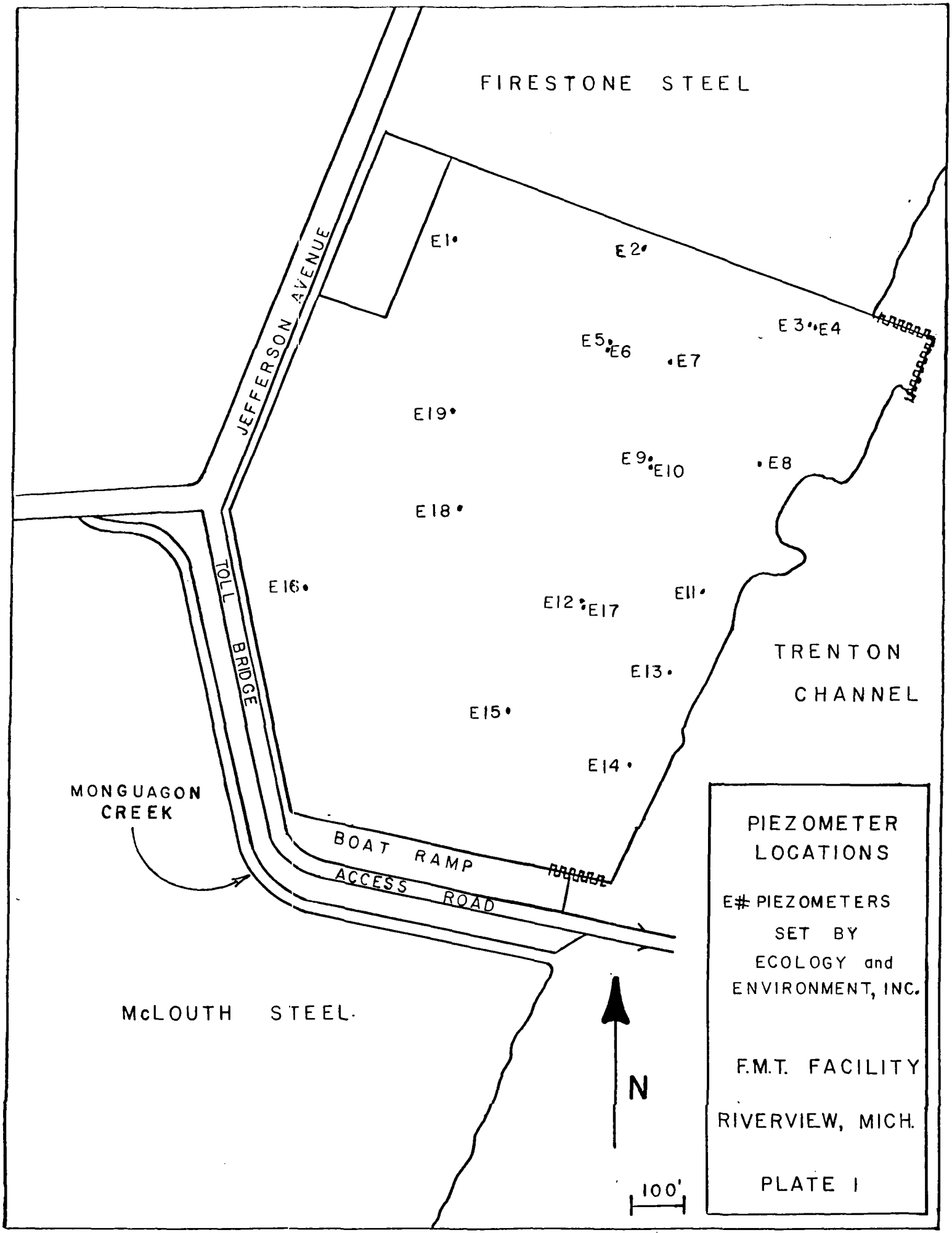


Figure 3B: F.M.T. Site; Generalized Ground Conductivity Contour Plot
Northeast corner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JEFFERSON AVENUE
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TOLL BRIDGE
TRENTON CHANNEL
MONGUAGON CREEK
BOAT RAMP ACCESS ROAD
McLOUTH STEEL
N
100'
PIEZOMETER LOCATIONS
E# PIEZOMETERS SET BY ECOLOGY and ENVIRONMENT, INC.
F.M.T. FACILITY
RIVERVIEW, MICH.
PLATE 1

Soil Boring and Well Installation (continued)

Wells were constructed of 3' stainless steel screens and galvanized steel pipe which were sprayed with acetone before placement in the hole. The screened interval was packed with gravel, a bentonite layer was deposited over the gravel, and the hole was grouted to the surface. Well security was provided by a locking outer well casing. General well construction is illustrated in Diagram 1. All wells were developed by bailing.

Presented in Table 1 are the results of the chemical analysis done on soil samples taken from wells, #1, 3, 5, 6, 7, 8, 10 and 15. As can be seen, the highest concentration of priority pollutants were found in samples from well #10 and #15. Samples from wells #7 and #8 also contained measurable amounts of several organic compounds from the priority pollutant scan. Contaminated soils in wells #7, 8 and 10 coincide with the area where the majority of any on-site disposal was thought to have occurred.

The occurrance of contaminated soils in the vicinity of well #15 coincides with a secondary disposal area thought to be on the southern portion of the property. Both magnetometric anomelies and high conductivities in the area had indicated the possible occurrance of contamination.

Table 2 presents the results of sieve analysis performed on soil samples from borings #7, 10, and 18. Shelby tube samples of the underlying clay were obtained from borings #16, 17 and 19, and Table 3 presents the results of permeability tests which were run on these samples. As would be expected with filled areas, the composition of the soils varies greatly. However, the clay was observed to have a permeability of approximately 2 x 10^{-8}cm/sec in all three tested samples. All previously completed on-site soils investigations have shown the clay to be 30'-50' thick.[1] In order to obtain a representative value of permeability of the fill material, in-situ falling head tests were performed in wells #3 and 7. These tests (see Appendix B) resulted in values of 5 x 10^{-5}cm/sec in well #7 and approximately 3.5 x 10^{-5} in well #3. Values in this range are normal for materials composed of silty sands.

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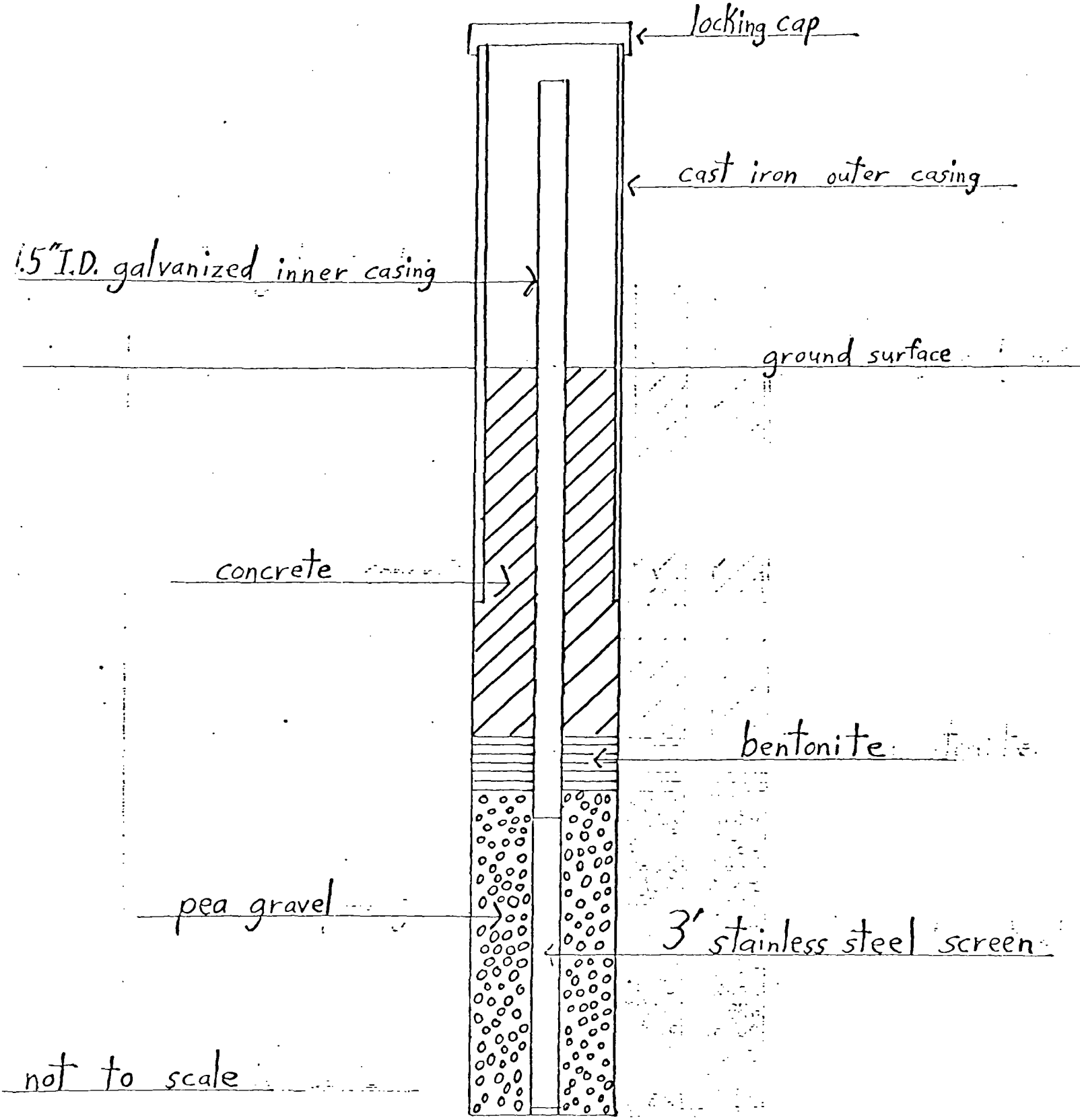
1 The combined effect of the low tested permeabilities and large thickness of the clay will be to prevent vertical migration of groundwater from the surficial deposits.

Federal Marine Terminals



not to scale

TABLE 1

Priority Pollutants Found in Soil Samples in PPM

Parameters	Well Numbers							
	1	3	5	6	7	8	10	15
Acenaphthene							1.0	31
1,4-dichlorobenzene								3.6
Fluoranthene					0.67		2.0	1.9
Isophorne								1.5
Napthalene					2.6	0.57		2.4
di-n-butyl phthalate		2.2						
Benzo(a)anthracene/chrysene							0.58	1.3
Anthracene/phenanthrene					1.7		5.6	4.4
Fluorene							1.2	0.85
3,4-benzofluoranthene/benzo(k)fluoranthene								0.80
Pyrene							1.2	1.4
1,2-dichloroethane (PPB)							15	
Ethylbenzene					7.1			
Methylene Chloride (PPB)		2.4	67	6400		15	16	
Toluene					6.3			
PCB-1260						9		
Calcium (PPT)	6.1	8.3	10	28	37	110	19	140
Magnesium (PPT)	3	8.4	9.2	2.9	3.1	14	7.2	13
Sodium (PPT)	12	5.1	5.9	17	13	3.1	5	9.4
Potassium (PPT)	4	6.7	6.4	3.1	2.8	1.7	3	3.5
Aluminum (PPT)	37	59	58	26	28	22	22	32
Iron (PPT)	13	26	30	12	12	18	5.6	20
Silver	<2.8	<2.8	<3	<2.9	<3	<3	<2.9	<2.9
Barium	360	430	420	300	270	230	300	280
Beryllium	3.1	4.1	4.1	3.1	2.9	2.6	2.5	37
Cadmium	4.9	<1.9	<2	<1.9	<2	<2	<1.9	<2
Cobalt	12	25	37	9.2	10	11	8.4	18
Chromium	40	77	60	35	24	62	31	110
Copper	87	77	94	95	75	340	76	120
Manganese	130	280	210	120	170	370	130	370
Nickel	<14	33	30	<14	<15	23	<15	20
Lead	<94	<94	<99	310	<99	130	<97	<98
Tin	100	120	230	120	75	64	80	59
Strontium	140	120	150	200	133	270	130	270
Titanium	700	3300	3200	1400	1600	1400	1300	1800
Vanadium	<18	110	110	53	58	60	48	73
Tungsten	<47	<47	100	26	<50	<50	<49	53
Yttrium	12	21	26	12	17	17	14	21
Zinc	64	99	110	130	80	290	44	140
Zirconium	170	130	190	120	250	110	130	100
Arsenic	<2	<2	<2	<2	<2	<2	<2	<2
Selenium	4.8	5.6	<2	<2	<2	<2	<2	<2
Antimony	<2	<2	<2	<2	<2	<2	<2	<2
Thallium	2.8	<2	<2	<2	<2	<2	2.4	<2
Mercury	0.04	.12	1.3	12		33	1.0	0.9

Table 1 OK

Priority Pollutants Found In Soil Samples in PPM

Parameters	Well Numbers							
	1 or N.D.	3	5	6	7	8	10	15
PCB-1260 (ppm)								
1,2-dichloroethene (ppb)								
methylene chloride (ppb)		2.4	67	400			16	
acenaphthene							1.0	31
1,4-dichlorobenzene								3.6
fluoranthene					0.67		2.0	1.9
isophorone								1.5
naphthalene	0.57				2.6			2.4
di-n-butyl phthalate								
Benzol(a)anthracene/Chrysene							.58	1.3
anthracene/phenanthrene					1.7		5.6	4.4
fluorene							1.2	0.85
3,4-benzofluoranthene/benzo(k)fluoranthene								
pyrene							1.2	1.4
ethylbenzene								
toluene					6.3			
Calcium (PPT)	6.1	8.3	10	28	37	110	19	140
Magnesium (PPT)	3	8.4	9.2	2.9	3.1	14	7.2	13
Sodium (PPT)	12	5.1	5.9	17	13	3.1	5	9.4
Potassium (PPT)	4	6.7	6.4	3.1	2.8	1.7	3	3.5
Aluminum (PPT)	37	59	58	26	28	22	28	32
Iron (PPT)	13	26	30	12	12	18	5.6	20
Silver	<2.8	<2.8	<3	<2.9	<3	<3	<2.9	<2.9
Barium	360	430	420	300	270	230	300	280
Beryllium	3.1	4.1	4.1	3.1	2.9	2.6	2.5	37
Cadmium	4.9	<1.9	<2	<1.9	<2	<2	<1.9	<2
Cobalt	12	25	37	9.2	10	11	8.4	18
Chromium	40	77	60	35	24	62	31	110
Copper	87	77	94	95	75	340	76	120
Manganese	130	280	210	120	170	370	150	370
Nickel	<14	33	30	<14	<15	23	<15	20
Lead	<94	<94	<99	310	<99	130	<97	<98
Tin	100	120	230	120	75	64	80	59
Strontium	140	120	150	200	133	270	130	270
Titanium	700	3300	3200	1400	1600	1400	1300	1800
Vanadium	<18	110	110	53	58	60	48	73
Tungsten	<47	<47	100	26	<50	<50	<49	53
Yttrium	12	21	26	12	17	17	14	21
Zinc	64	99	110	130	80	290	44	140
Zirconium	170	130	190	120	250	110	130	100
Arsenic	<2	<2	<2	<2	<2	<2	<2	<2
Selenium	4.8	5.6	<2	<2	<2	<2	<2	<2
Antimony	<2	<2	<2	<2	<2	<2	<2	<2
Thallium	2.8	<2	<2	<2	<2	<2	2.4	<2
Mercury	0.04	.12	1.3	12		33	1.0	0.9

TABLE 2

MECHANICAL ANAYLSIS (SEIVE AND HYDROMETER) AND COMPOSITION OF SOIL

Sieve Analysis

Percent Passing Sieve Size and Numbers

Boring Number	1 1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.10	NO.20	NO.40	NO.100	NO.200
7-A	100.00	100.00	100.00	100.00	100.00	99.91	99.45	99.36	99.24	77.63	53.69
10-B	100.00	100.00	100.00	100.00	100.00	99.47	98.25	97.55	97.08	42.86	21.73
18-D	100.00	90.66	86.91	80.76	75.46	63.51	47.49	39.03	33.77	26.99	22.15

COMPOSITION OF SOIL

BORING NUMBER	GRAVEL (%)	SAND (%)	FINES SILT (%)	FINES CLAY (%)
7-A	0.55	45.76	34.21	19.48
10-B	1.75	76.52	10.70	11.03
18-D	52.51	25.34	10.54	11.61

TABLE 3

PERMEABILITY TEST

Boring Number	Sample Number	Depth (FT.-IN.)	Natural Moisture Content (%)	Coefficient of Permeability (cm/sec)
16	ST-1	4'4"-6'0"	15.4	2.0×10^{-8}
17	C	14'0"-15'6"	15.5	1.8×10^{-8}*
19	ST-1	5'9"-6'10"	18.4	2.1×10^{-8}

* Sample remolded and consolidated at the approximate overburded pressure of $^{-8}_{v}$ =1,500 psf for 24 hours prior to test

Soil Boring and Well Installation (continued)

Logs of the soil borings (Appendix A) reveal a clay-fill interface surface as shown on Plate 2. The northwestward trending depression across the clay suggests the presence of the ancestral Monguagon Creek across the property at this location. Several of the borings penetrated a soft, black, organic layer at approximate elevation 573-574. As this elevation coinsides with approximate river level and the lateral extent of this organic layer is relatively extensive, it is believed that this elevation represents the deepest extent of fill material. Sand and gravel deposits below the organics probably represent naturally deposited alluvial materials.

Plate 3 is a contour plot of the piezometric surface as defined by water level measurements taken on 2/24/81 and 2/27/81. The piezometric surface depicted, verifies the split groundwater flow system as suggested by Dames and Moore. On the western portions of the site, groundwater flow is toward the north. The eastern portion of the site is characterized by groundwater flow toward the river. The correlation between the piezometric surface and the clay-fill interface suggests that groundwater flows across the site on top of the clay. As outlined in Appendix C, the volume of water flowing from the site into the Trenton Channel is approximately 56,000 gallons/year at an estimated velocity of 4 feet/year. It should be emphasized that these figures represent estimates based on the assumptions outlined in Appendix C.

The relative elevations of the piezometric surface and river level suggest that at the time this data was collected, water was moving from the channel into the near stream alluvial deposits and fill material. Communication between the two will naturally result in occassional recharge of the groundwater in this manner.

Soil Boring and Well Installation (continued)

Logs of the soil borings (Appendix A) reveal a clay-fill interface surface as shown on Plate 2. The northwestward trending depression across the clay suggests the presence of the ancestral Monguagon Creek across the property at this location. Several of the borings penetrated a soft, black, organic layer at approximate elevation 573-574. As this elevation coincides with approximate river level and the lateral extent of this organic layer is relatively extensive, it is believed that this elevation represents the deepest extent of fill material. Sand and gravel deposits below the organics probably represent naturally deposited alluvial materials.

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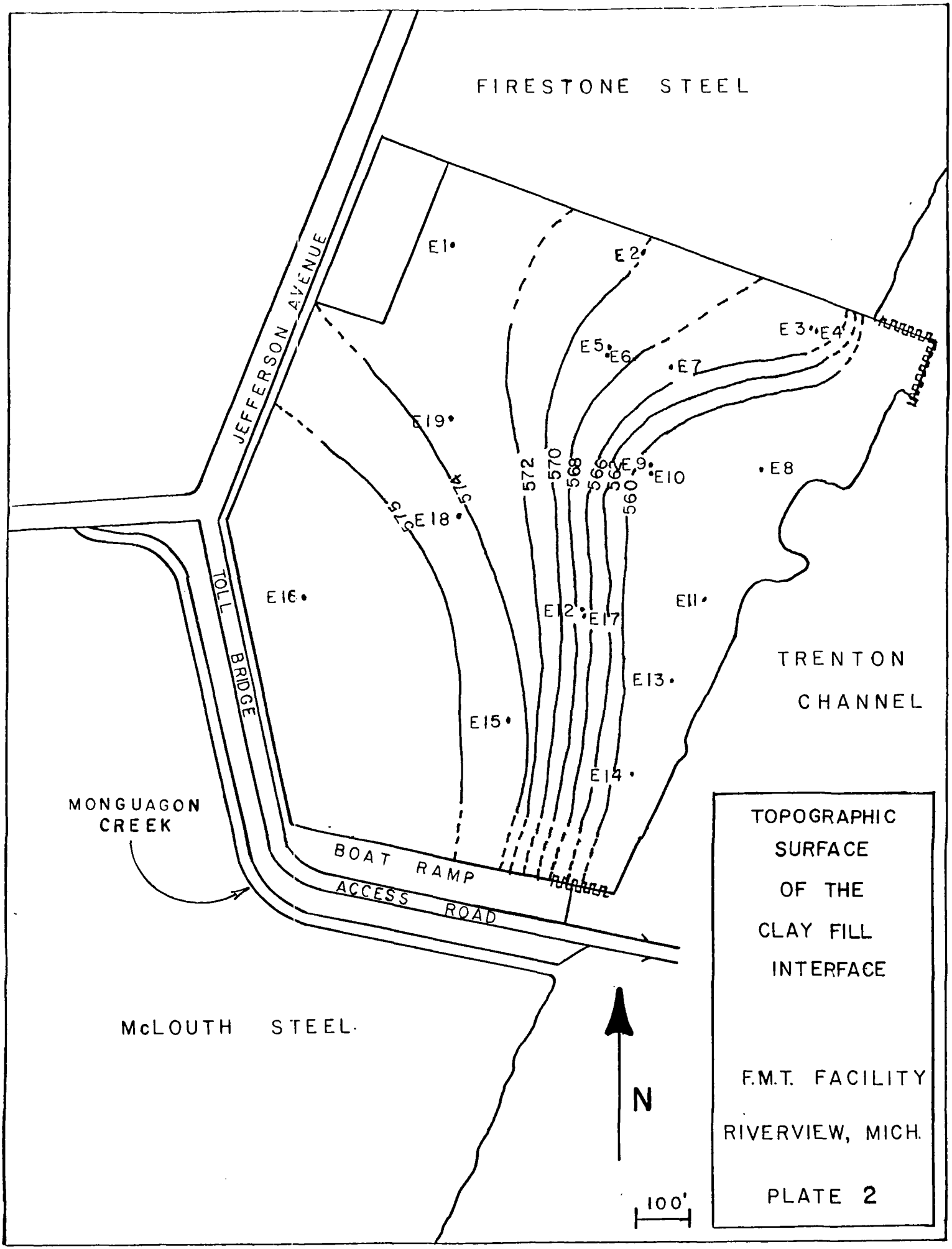
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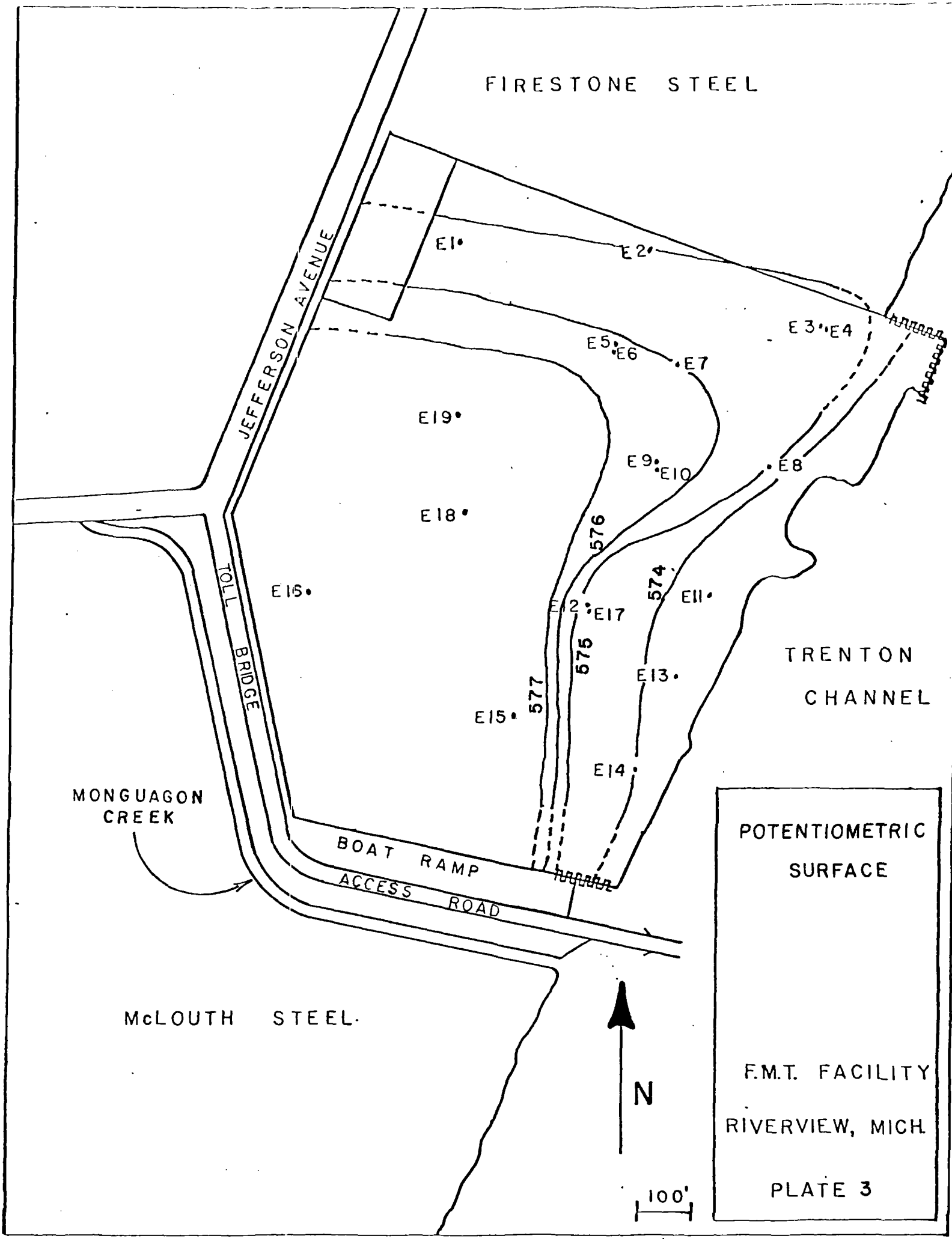
TOLL BRIDGE
MONGUAGON CREEK
BOAT RAMP ACCESS ROAD
TRENTON CHANNEL
McLOUTH STEEL
N
100'
TOPOGRAPHIC SURFACE OF THE CLAY FILL INTERFACE
F.M.T. FACILITY
RIVERVIEW, MICH.
PLATE 2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TOLL BRIDGE
TRENTON CHANNEL
MONGUAGON CREEK
BOAT RAMP
ACCESS ROAD
McLOUTH STEEL
N
100'
POTENTIOMETRIC SURFACE
F.M.T. FACILITY
RIVERVIEW, MICH.
PLATE 3

Groundwater Sampling

At the conclusion of the soil boring and well installation portion of the study, wells #1, 2, 6, 9, 11, 16, and 18 were sampled. Prior to obtaining each sample, each well was bailed until at least three volumes had been removed or dry. After sufficient time had been allowed for recharge, samples were taken with stainless steel bailers which had been cleaned with distilled water and methylene chloride. The samples were then preserved (as necessary), packed, and shipped via Federal Express with custody seals in place. Each sample was analyzed for the USEPA priority pollutants. Additionally, the twenty highest non-priority pollutants were identified.

The results of the analysis are shown on Table 4. As can be seen from the analysis, the highest concentrations of many contaminants occurred in water from wells #6, 9, 11, and 18. The areal distribution among the wells of nine contaminants is plotted on Plate 4. Groundwater entering the site from the upgradient areas southwest of the site is relatively free of contamination as shown in well #16. As the groundwater moves laterally accross the site, that water which crosses the suspected disposal areas of the northeast quadrant picks up contamination. The lowered concentrations found in the near river samples are thought to represent the effects of mixing between contaminated groundwater and river water as previously suggested.

Conclusions

The data which has been collected to date is sufficient to allow conclusions about the groundwater characterisitics and geologic setting of the FMT site to be drawn. The property is underlain by a stiff clay layer which extends for 30'-50' below the fill and has a measured permeability on the order of 2×10^{-8} cm/sec. This layer should be sufficient to prevent vertical migration of contaminants. The clay surface is overlain by silty sand, sand and gravel, and mixed fill deposits. The deepest sand and gravel deposits in the clay depression are probably naturally occuring alluvial deposits of the Trenton Channel or ancestral Monguagon Creek. The organic layer encountered in several borings probably represents the

TABLE 4

Detected Priority Pollutants in Groundwater in PPB

Compounds	WELLS #1	#2	#6	#9	#11	#16	#18
p-chloro-m-cresol		339					
2-chlorophenol		29					
2,4-dichlorophenol		364		522			
pentachlorophenol			121	802		1100	
phenol		2370	227	4400	526		424
bis(2-chloroethyl)ether			271				
fluoranthene	19		434	15000	370		1675
napthalene			429	24000	330		400
N-nitrosodiphenylamine			88				
bis(2-ethylhexyl)phthalate	51		566	3100	950		2700
benzo(a)anthrancene	45		396				600
di-n-butyl phthalate			32		230		400
benzo(a)pyrene	62						760
benzo(k)fluoranthene/3,4-benzofluoranthene	34		284	3900	150		550
chrysene				7000			900
acenaphthylene			73	5400			163
anthracene/phenanthrene			799	10000	310		835
benzo(ghi)perylene			143				
fluorene			93	4100			211
indeno(1,2,3-cd)pyrene			123				
pyrene	21		347	20500	500		2150
benzene		280	27		195	190	174
chlorobenzene					84		
ethyl benzene			13				648
methylene chloride		290	56	3800	1000	880	580
tetrachloroethylene			23				139
toluene		64	597		69		430
endosulfan sulfate				32			19
heptachlor							12
-BHC					22		16
-BHC					19		
PCB (total)			140	215			47
calcium (ppm)	41.3	134	677	2280	1990	295	1670
magnesium (ppm)	97	10.6	8.1	81.1	194	144	49.7
sodium (ppm)	43000	16600	20100	17700	5120	2380	11300
silver	140	<300	<20	450	359	<300	<300
aluminum	10200	27000	12700	158000	402000	39300	84400
boron	2050	82900	4290	23100	28300	<8000	<8000
barium	80	648	640	5900	20900	551	3950
berylium	<2	<100	2	<100	<100	<100	<100
cadmium	<5	<200	5	279	313	255	<200
cobalt	20	<500	50	<500	<500	<500	<500
chromium	80	5450	240	1470	6930	<800	1900
copper	120	1570	1760	1600	9260	1140	1470
iron	25000	56800	23200	170000	752000	51400	131000
manganese	530	701	540	3720	11100	1820	1970
molybdenum		1300		<1000	<1000	<1000	<1000
nickel	260	14800	420	2250	2750	1850	4120
lead	280	<7000	1880	7080	22400	<7000	<7000
tin	<5000	<4000	<500	<4000	<4000	<4000	<4000
titanium		860		6260	9520	681	4070
vanadium	110	17100	840	1790	1070	<500	1190
yttrium		<500		<500	<500	<500	<500
zinc	3650	<400	6230	15000	31300	23700	<400
arsenic	500		750				
antimony	300		20				
selenium	1200		30				
thallium	<200		<200				
mercury	4	20	5000	800	800	25	1600
cyanide	31000		14000				

Conclusions (continued)

upper most horizon of these alluvial deposits and marks the lowest extent of filled materials. Fill materials encountered on site ranged from silty sands to gravels, bricks, etc. Evaluation of falling head tests on two of the wells yielded values on the order of 10^{-5}cm/sec.

Relatively clean groundwater enters the property from the southwest. As it crosses the property, the water follows the top of the clay surface toward the north and east. That portion of the groundwater which flows across the northeast quadrant of the site does pick up contamination. These contaminants are transported through the groundwater of the Trenton Channel of the Detroit River. The horizontal movement of groundwater into the river will be approximately 0.1 gal/minute. At flow rates in this range, there is little possibility of detecting any groundwater induced contamination in the river.

Recommendations

I. The wells in the southeast quadrant of the property should be sampled in order to define the type of groundwater contamination associated with the contaminated soils in well #5.

II. Water levels in all wells should be remeasured to access the impact of any topographic changes which have been made to the site.

III. The possibility of placing at least one piezometer in the vicinity of the Firestone Steel plant should be explored. This would give some indication as to the direction of groundwater flow to the north of the FMT property.

RB/lls

REFFERENCES

1) Technos, Inc., 1980, "Report of Geophysical Investigation at F.M.T., Firestone and McLouth Steel Properties," Detroit, Michigan.

2) Freeze, R. Allan and Cherry, John A., 1979, "Groundwater," Prentice-Hall, Inc., Englewood Cliffs, N.J., p. 29.

3) Detailed description of preservation and analytical techniques were supplied to all interested parties by E.P.A.

4) Dames and Moore, 1979, "Investigation of Potential Contamination - Firestone Site," Riverview, Michigan.

Applied Environmental Research, 1979, "Federal Marine Terminals, Inc. Site Environmental Assessment," Riverview, Michigan.

Walton, W. C., 1970, "Groundwater Resource Evaluation," McGraw Hill Book Company, p. 664.

RB/lls

A P P E N D I X A

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location - **Job No.** DR-4686

Date JANUARY 14, 1981 **Soil Boring No.** 1

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 590.60					
	1'0"	Fill - medium stiff brown silty clay	(3)				
NO.1 J			(3)				
	2'6"		(3)				
	3'6"	Fill - medium stiff grey silty clay	(2)				
NO.2 J			(3)				
	5'0"		(4)				

Type of Sample

- A Auger (Disturbed) —Split Tube Sampling—
- H Thin-walled (Housel) Tube-Undisturbed
- J Jar-Disturbed
- ST Shelby Tube-Undisturbed
- RC Rock Core
- NR Indicates "No Recovery"

Remarks

Total Footage: 5'0"
Overburden Drilled: 5'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

At completion: 3'6" below the ground surface

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

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Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 15, 1981 **Soil Boring No.** 2

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 589.95					
	1'6"						
NO.1 J		Fill - very loose dark brown sand and gravel	(6) (2)				
	3'0"		(1)				
	4'0"						
NO.2 J	5'0"		(5) (3)				
	5'6"	Soft brown silty clay	(2)				

Type of Sample

- A Auger (Disturbed) —Split Tube Sampling—
- H Thin-walled (Housel) Tube-Undisturbed
- J Jar-Disturbed
- ST Shelby Tube-Undisturbed
- RC Rock Core
- NR Indicates "No Recovery"

Remarks

Total Footage: 5'6"
Overburden Drilled: 5'6"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
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Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 15, 1981 **Soil Boring No.** 3

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 589.93					
	1'6"	Fill - Medium dense brown sand and gravel					
NO.1 J			(10) (7)				
	3'0"		(5)				
	4'0"						
NO.2 J		Fill - very loose sand, gravel and clay	(2) (1)				
	5'6"		(1)				
	8'6"						
	9'0"						
NO.3 J		Medium stiff grey silty, sandy clay	(2) (2)				
	10'6"		(3)				

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 10'6"
Overburden Drilled: 10'6"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
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Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 15, 1981 **Soil Boring No.** 4

Sample & Type	Depth (Ft.-In.)		Top of well cap - Elevation: 589.23 Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
			Fill - dark brown sand, gravel, clay, rock and brick					
	4'0"							
NO.1				(15)				
J				(15)				
	5'6"			(9)				
	6'0"							

Type of Sample

A Auger (Disturbed) —Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

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Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 15, 1981 **Soil Boring No.** 5

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 590.42					
	4'0"	Fill - very loose dark brown sand and gravel					
NO.1 J			(4) (1)				
	5'6"		(1)				
	7'6"						
	9'0"	Soft grey silty clay					
NO.2 J			(1) (2)				
	10'6"		(2)				
	11'6"						
	13'6"	Hard brown and grey mottled silty clay, some gravel					
NO.3 J			(14) (10)				
	15'0"		(17)				

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 15'0"
Overburden Drilled: 15'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 16, 1981 **Soil Boring No.** 6

Sample & Type	Depth (Ft.-In.)		Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
			Top of well cap - Eelevation: 590.18					
			Fill - loose brown sand and gravel, trace of clay					
	4'0"							
NO.1				(3)				
J				(3)				
	5'6"			(3)				
	6'0"							

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

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Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 16, 1981 **Soil Boring No.** 7

Sample & Type	Depth (Ft.-In.)	Top of well cap - Elevation: 590.39 Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
	2'0"	Fill - brown sand, gravel and stone					
	4'0"	Soft black sand and silt, some clay and organics					
NO.1 J			(1) (1)				
	5'6"		(2)				
	9'0"	Medium stiff brown sand and silt, little clay, trace of gravel					
NO.2 A, J			(1) (2)				
	10'6"		(4)				

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 10'6"
Overburden Drilled: 10'6"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 16, 1981 **Soil Boring No.** 8

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 589.45					
	4'0"	Fill - loose brown and black sand, gravel and clay					
NO.1			(4)				
J			(2)				
	5'6"		(4)				
	7'0"						

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 7'0"
Overburden Drilled: 7'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
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Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 16, 1981 **Soil Boring No.** 9

Sample & Type	Depth (Ft.-In.)		Top of well cap - Elevation: 591.00 Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
			Fill - brown sand and gravel					
	2'0"							
			Loose brown and black sand and gravel, trace of silty clay					
	4'0"							
NO.1 J				(6) (2) (4)				
	5'6"							
	6'0"							

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 21, 1981 **Soil Boring No.** 10

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of wall cap - Elevation: 590.93					
	4'0"	Light brown sand, gravel and stones					
NO.1 J			(7) (7) (9)				
	5'6"						
	7'0"						
	8'6"	Very soft black organic muck					
	9'0"						
NO.2 J			(3) (2)				
	10'6"		(2)				
	14'0"	Fill - loose black sand, little silt and clay, trace of gravel					
NO.3 B, J			(4) (2)				
	15'6"		(3)				

Type of Sample

- A Auger (Disturbed) —Split Tube Sampling—
- H Thin-walled (Housel) Tube-Undisturbed
- J Jar-Disturbed
- ST Shelby Tube-Undisturbed
- RC Rock Core
- NR Indicates "No Recovery"

Remarks

Total Footage: 15'6"
Overburden Drilled: 15'6"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location - **Job No.** DR-4686

Date JANUARY 21, 1981 **Soil Boring No.** 11

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of wall cap - Elevation: 589.76					
	2'0"						
NO.1 J		Fill - loose black sand and gravel, brick and rock	(6)				
	3'6"		(5)				
			(3)				
	5'0"						
		Black sand and gravel					
	8'6"						

Type of Sample

A Auger (Disturbed) —Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 8'6"
Overburden Drilled: 8'6"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 21, 1981 **Soil Boring No.** 12

Sample & Type	Depth (Ft.-In.)		Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
			Top of wall cap - Elevation: 590.86					
			Loose brown and white sand and gravel					
	4'0"							
NO.1 J				(1)				
	5'6"			(1)				
	6'0"			(4)				

Type of Sample

A Auger (Disturbed) —Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 21, 1981 **Soil Boring No.** 13

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of wall cap - Elevation: 591.04					
		Fill - dark brown sand, gravel, rock brick and steel					
	5'6"						
NO.1 J			(1) (19)				
	7'0"		(12)				
	8'6"						

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 8'6"
Overburden Drilled: 8'6"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ Job No. DR-4686

Date JANAURY 21, 1981 Soil Boring No. 14

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 591.85					
	4'0"	Fill - black sand, gravel and stone					
NO.1 J							
	5'6"						
	6'0"						

Type of Sample

A Auger (Disturbed) —Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 21, 1981 **Soil Boring No.** 15

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 591.77					
		Fill - sand, gravel and brick					
	3'0"						
		Black sand and organic muck					
	4'0"						
NO.1 J		Medium stiff black sandy clay	(4) (5) (3)				
	5'6"						
	6'0"						

Type of Sample

A Auger (Disturbed) —Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 22, 1981 **Soil Boring No.** 16

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 591.17					
		Black silty clay, trace of sand					
	3'0"			15.4			
	4'4"	Hard brown silty clay					
NO.1 ST	6'0"						

Type of Sample

- A Auger (Disturbed)
- —Split Tube Sampling—
- H Thin-walled (Housel) Tube-Undisturbed
- J Jar-Disturbed
- ST Shelby Tube-Undisturbed
- RC Rock Core
- NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.
1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 22, 1981 **Soil Boring No.** 17

Top of well cap - Elevation - 590.86

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
	8'0"	Fill - loose brown sand and gravel, some stones					
NO.1 J			(13)				
	9'6"		(3) (4)				
	12'0"						
	14'0"	Grey silty clay, some gravel					
NO.2 C, J							
	15'6"						
	18'0"						

Type of Sample

A Auger (Disturbed) —Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 18'0"
Overburden Drilled: 18'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 22, 1981 **Soil Boring No.** 18

Sample & Type	Depth (Ft.-In.)	Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
		Top of well cap - Elevation: 591.05					
		Fill - grey sand, gravel and stone					
	3'0"						
	4'0"	Fill - black gravel, some sand, little silt and clay					
NO.1 D, J	5'6"						
	6'0"						

Type of Sample

A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 6'0"
Overburden Drilled: 6'0"
Rock Cored: NONE
Drillers: TK-TB-DF

Groundwater Observations

SOIL BORING LOG

Toledo Testing Laboratory, Inc.

1810 North 12th Street
Toledo, Ohio 43624
(419) 241-7175

Project WELL INSTALLATION - RIVERVIEW, MICHIGAN

Boring Location _____ **Job No.** DR-4686

Date JANUARY 22, 1981 **Soil Boring No.** 19

Sample & Type	Depth (Ft.-In.)		Soil Description	Blows Per 6"	Moisture Content (%)	Dry Unit Weight (P.C.F.)	Unconfined Compressive Strength (P.S.F.)	Allowable Bearing Strength (P.S.F.)
			Fill - black sand, gravel and brick					
	3'0"							
			Grey sand					
	4'0"							
			Grey silty clay, little gravel					
NO.1 ST	5'9"				18.4			
	6'10"							
	7'0"							

Type of Sample

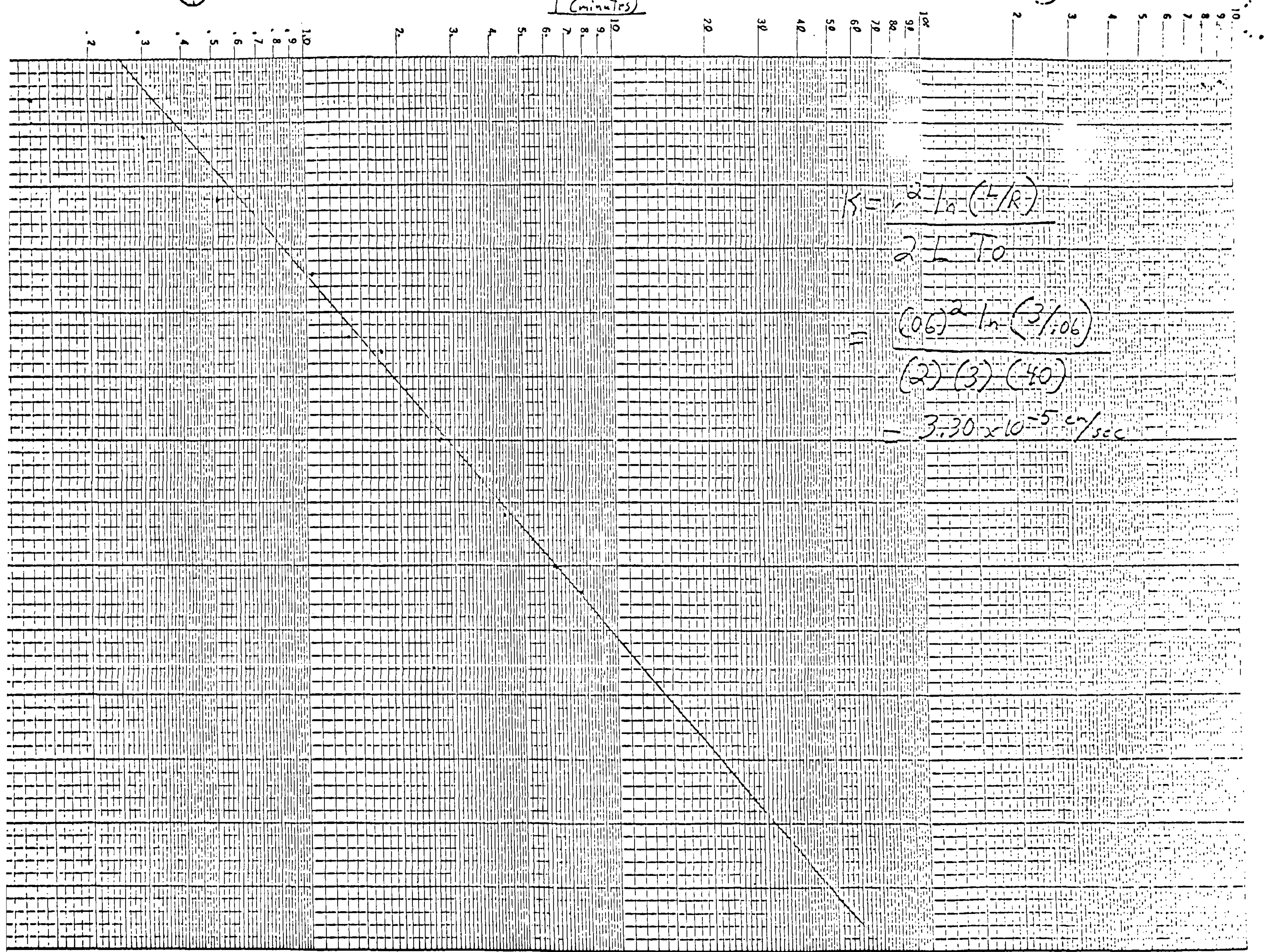
A Auger (Disturbed)
—Split Tube Sampling—
H Thin-walled (Housel) Tube-Undisturbed
J Jar-Disturbed
ST Shelby Tube-Undisturbed
RC Rock Core
NR Indicates "No Recovery"

Remarks

Total Footage: 7'0"
Overburden Drilled: 7'0"
Rock Cored: NONE
Drillers: TK-TB-DF

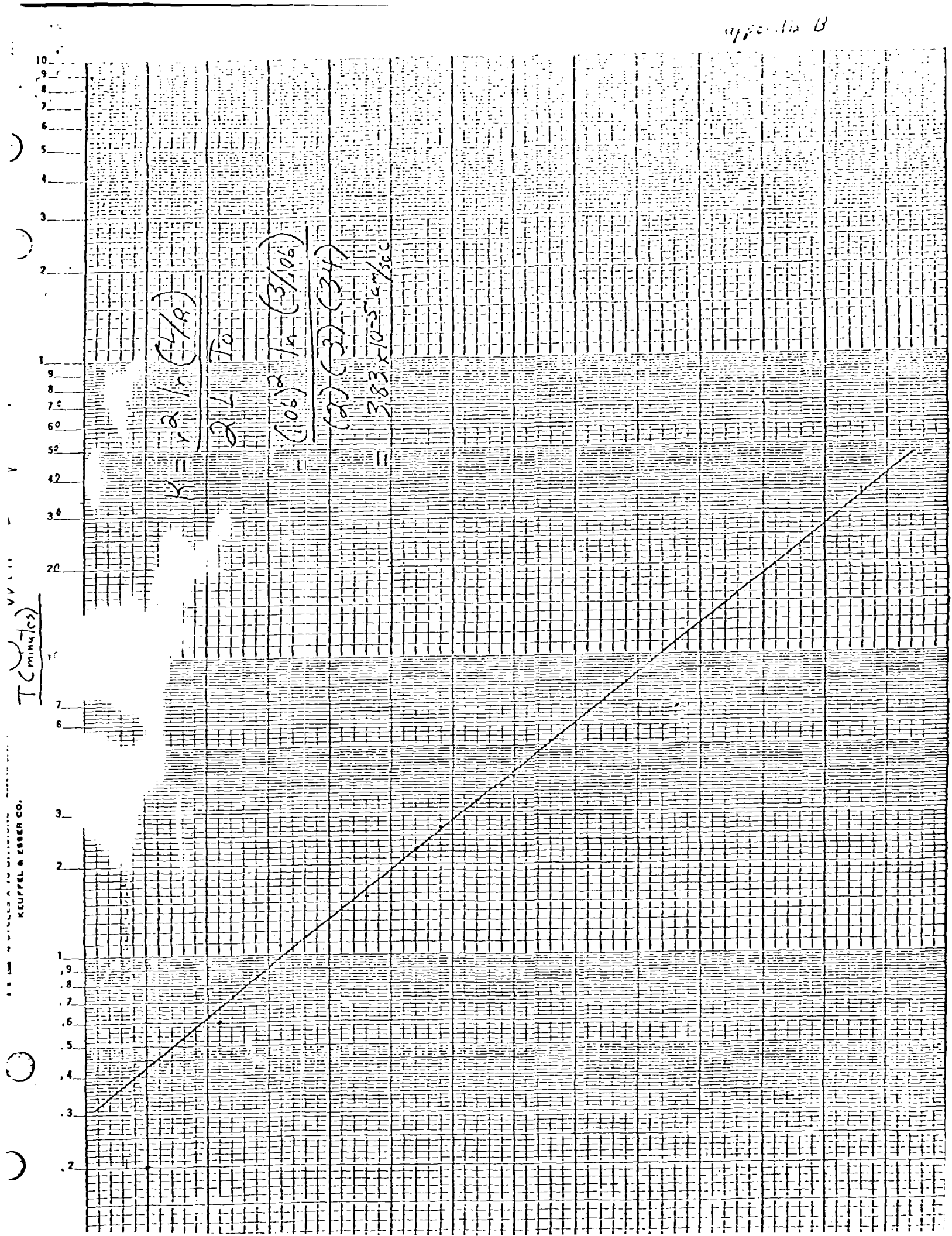
Groundwater Observations

A P P E N D I X B


T (minutes)
$K = \frac{r^2 \ln(L/R)}{2 L T_0}$
$= \frac{(.06)^2 \ln(3/.06)}{(2)(3)(40)}$
$= 3.30 \times 10^{-5}$ cm/sec

T = 40

Appendix B



KEUFFEL & ESSER CO.

K+E SEMI-LOGARITHMIC 46 6010
4 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

Well #7 Run #1

T (minutes)

$$K = \frac{r^2 \ln(L/R)}{2L\,T_0}$$

$$= \frac{(6.6)^2 \ln(3/.01)}{(2)(3)(25.8)}$$

$$= 5 \times 10^{-5}\ \text{cm/sec}$$

T - 25.8 minutes

Well 7 Run 2

(T minutes)

$$K = \frac{r^2 \ln(t/R)}{2 L T_o}$$

$$= \frac{(.06)^2 \ln(3/.02)}{(2)(3)(25.5)}$$

$$= 5 \times 10^{-5} \text{ cm/sec}$$

$T_o = 25.5$ minutes

A P P E N D I X C

The volume of water discharged form the groundwater to the Trenton Channel of the Detroit River can be estimated using Dracy's Law:

$Q = -KIA$ where,

Q = volume of water, $feet^3/year$

K = hydraulic conductivity, cm/sec or ft/yr

I = hydraulic gradient

A = area through which groundwater discharge occurs, $feet^2$

V = specific discharge

ne = effective porosity

Assumptions:

$K = 4 \times 10^{-5}$ cm/sec or 40 ft/yr

I = .015

A = 11.5 ft x 1075 ft = 12363 ft^2

ne = 15%

Therefore:

$Q = 40$ ft/yr x .015 x 12363 ft^2

= 7418 ft^3/yr or approximately 56,000 gal/yr

To estimate the velocity that water is moving toward the channel we calculated the specific discharge using the same assumptions:

$V = -KI\frac{1}{ne}$

V = 40ft/yr x .015 x 6.67

V = 4 ft/yr

These figures represent what is probably a worst case estimate due to the fact that the gradient used is the steepest found on the site. Also, since the water level measurements from which this data is generated were taken in the spring, the total cross sectional area of the saturated zone above the clay is probably at or near it's greatest size.

RB/11s